

Structural Microfracture Detection via Mutual Microwave Emission by Revolving Antipodean Mini-Drone Platforms

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Introduction

Prior to a structural defect in an airframe becoming visible or even concerning, it tends to begin as a microfracture. These nascent fractures are likely to evade notice even upon close inspection using visual/microscopic techniques given that they are generally restricted to beneath the surface of the airframe.

Conventional airframe inspection, although effective, is highly time-consuming, is prone to error, and oftentimes fails to find airframe fractures until they have matured to the point where repair is costly. If a fracture in an airframe can be detected while still microscopic, a potential repair would likely be millions of dollars less costly. To date, it has not been practically achievable to detect fractures in such an early state of development.

Airframe inspection using a microwave-emission method may be frustrated by the use of radar-absorbent coatings frequently used on aircraft. A novel approach is required for performing thorough, rapid, lost-cost inspections of airframes with the object of these inspections being to detect fractures in their very earliest stage in order to reduce cost of maintenance of aircraft fleets over time. The newfound ability to hyper-collimate microwave beams lends itself to this application, particularly when combined with drone technology.

Abstract

Focused, high-power microwave beams directed from a pair transceivers toward one another, with each of these being placed aboard small drones designed to move about (in an antipodean position with relation to one-another) the exterior of a hangared aircraft to inspect aircraft elements such as the nose, wings, fuselage and stabilizers.

One would expect microwaves emitted by one platform to the other to be transformed in predictable ways by the metallic skin of the aircraft with the angle at which the microwaves pass through the aircraft skin and the thickness and composition of the skin at various points determining the extent to which microwaves are absorbed. In addition to absorptiometry, the measurement of the quantity of an energetic beam that is absorbed, other properties of EM such as polarity and frequency can be analyzed in order to detect the presence of microfractures. Being able to bombard the aircraft body with focused microwaves from an infinite variety of angles is essential for enabling such a microfracture detection apparatus due to the fact that alterations to received EM caused by the fractures themselves would be most pronounced when the beam(s)

happen to come into general alignment with the direction of the fracture (parallel with the fracture.)

The effect that one would most associate with the presence of a microfracture in regards to EM alteration would be the directional scattering of the angular momentum of parts of a focused microwave beam. The detector would be able capable of measuring the extent to which "hotspots" are generated by a potential microfracture, with areas of relatively intense EM being detected somewhat outside of the anticipated direction of travel of the beam. Some percentage of the beam would be expected to scatter in a symmetrical fashion as a result of interaction with the metallic body of the airframe, however, asymmetrical scattering (resembling the areas of focused light dancing on the bottom of a swimming pool) would be a tell-tale sign of the presence of a microfracture. Coupling this type of observation with a measurement of the angular momentum of the EM relative to the strike-point on the sensor would inform the operator of such an apparatus as to the three-dimensional position of the fracture as well as its length.

While it may seem sufficient to transmit microwaves for such a purpose in a single direction, reciprocal microwaves could be used ascertain which elements of scattering are due to the innate structure of the airframe and which are due to microfracture. Microfracture-driven anomalies in the detected EM could be expected to create exact mirror images when a beam is transmitted in the opposite direction along an identical vector. The presence of such mirror or mirror-like images could be used to algorithmically confirm the presence of a microfracture.

Microfracture Annealing

Once a microfracture is detected, it may be difficult to access the relevant area in order to affect a repair. Carbon nanotubes provide a potential solution to this problem as they may be used to access microfractures, deliver filler material and, finally, fill the void created by their own insertion as they are withdrawn.

Conclusion

Microfracture detection and repair would be a boon for aviation safety that would reduce the cost of fleet maintenance by billions of dollars over the next several decades, enhancing national security by freeing up those resources to be allocated to other applications.